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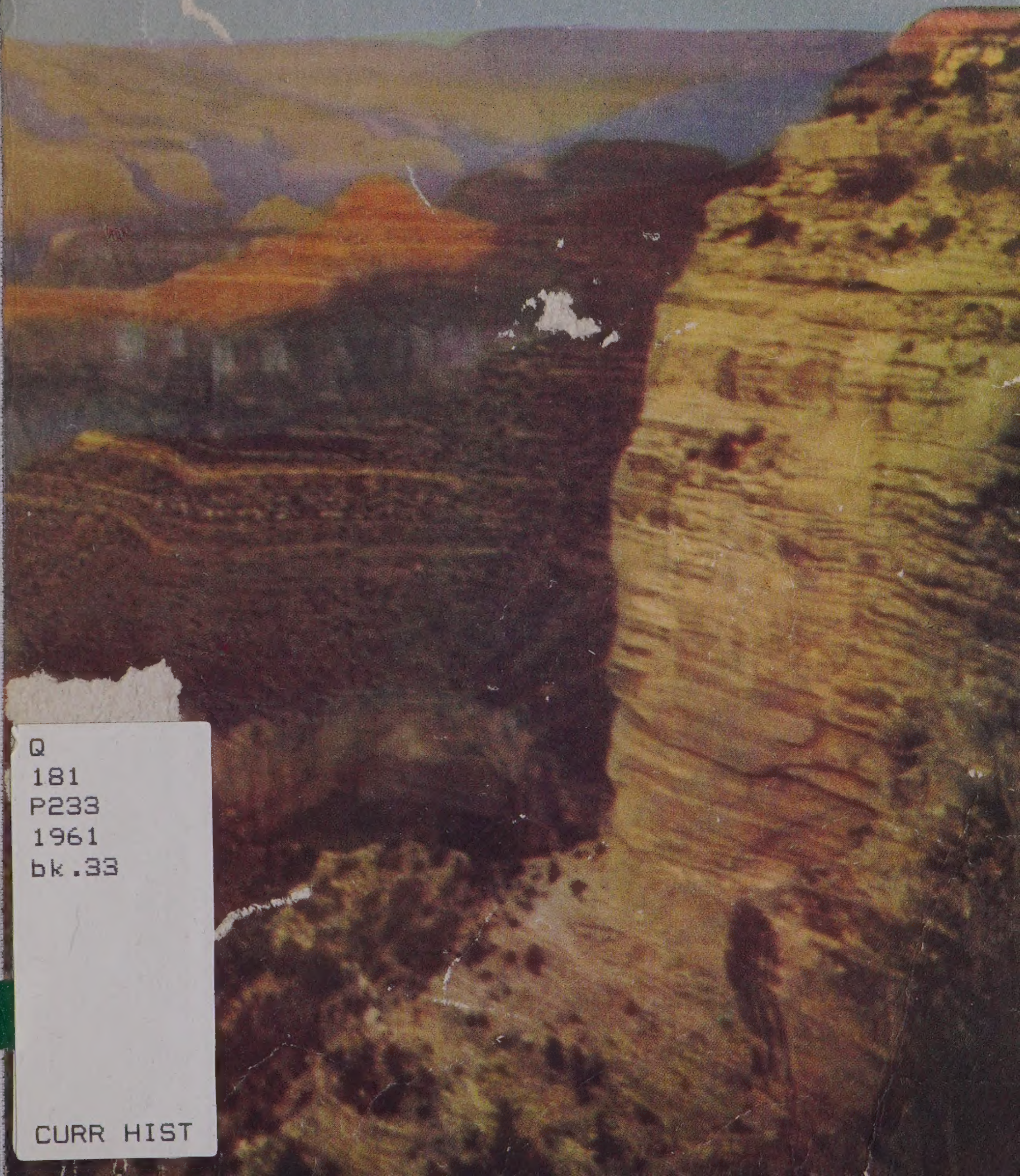
STORIES READ FROM THE ROCKS



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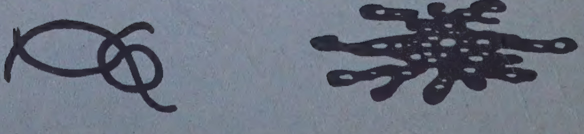
AGE OF SIMPLE PLANTS AND ANIMALS	

THE BASIC SCIENCE EDUCATION SERIES

STORIES READ FROM THE ROCKS

By

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LABORATORY SCHOOL, UNIVERSITY OF CHICAGO

Checked for Scientific Accuracy by

ELMER R. NELSON JR.
Milwaukee Public Museum

Intermediate

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Stories Read from the Rocks

The Story of a Trilobite

AGES AGO—so long ago that it would be hard for you to imagine how long ago it was—a *trilobite* lived in the water near the shore of a sea. What, you may say to yourself, is a trilobite? Perhaps you never heard of a trilobite before. It is certain that you never saw one alive, for the last trilobite died millions of years before you were born.

A trilobite was a little animal that had a hard covering much like that of a crab of today. This hard covering was divided lengthwise into three lobes. "Trilobite" means "three-lobed." Can you find the trilobite in the picture on page 2? The trilobite had long feelers and big eyes. It was not, as you can see, a very handsome creature.

Of course, the trilobite about which this story is told was not called a trilobite when it was alive. It was not called anything at all, for the very good reason that there were no people at that time to give it a name. It got its name millions of years after it died.

This little trilobite was not alone in the sea. It had thousands of trilobite neighbors. Some of its trilobite neighbors were exactly like it. Others were somewhat different. The trilobite had many other neighbors, too. Some of these neighbors were queer animals that disappeared long ago. Others were very much like some of the animals we find along the seashore today.

The picture on page 2 shows a few of the trilobite's neighbors. Notice the animal with arms and a coiled shell. This animal is an ancient relative of the squids of today. The animals which look like stems of plants with blossoms at the top are sea lilies. Sea lilies were common at the time our trilobite lived.

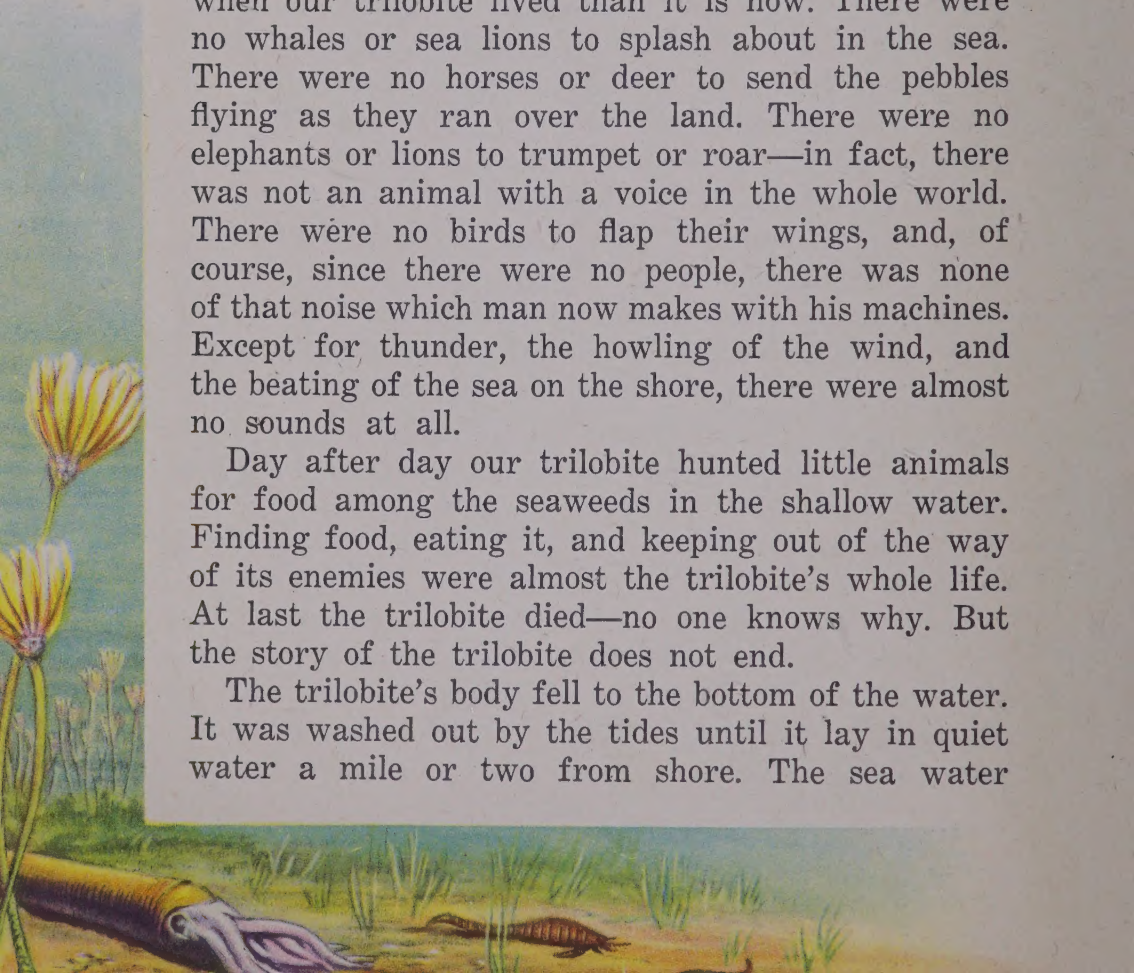
The picture shows, too, a mass of rock built by tiny animals called corals. There were many corals in the days of our trilobite.

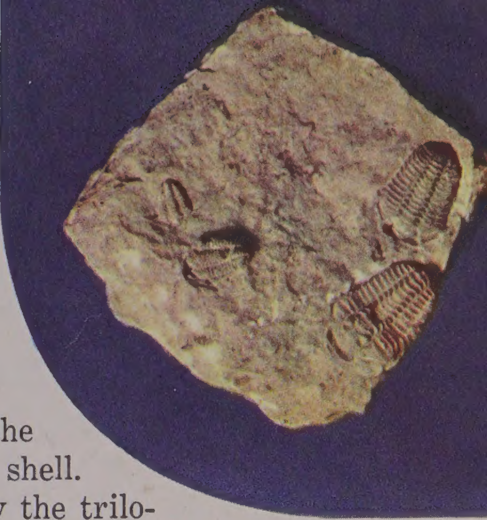
Among the trilobite's other neighbors were sponges, jellyfishes, and snails. There were also many animals somewhat like our clams.

The earth was a much quieter place in the days when our trilobite lived than it is now. There were no whales or sea lions to splash about in the sea. There were no horses or deer to send the pebbles flying as they ran over the land. There were no elephants or lions to trumpet or roar—in fact, there was not an animal with a voice in the whole world. There were no birds to flap their wings, and, of course, since there were no people, there was none of that noise which man now makes with his machines. Except for thunder, the howling of the wind, and the beating of the sea on the shore, there were almost no sounds at all.

Day after day our trilobite hunted little animals for food among the seaweeds in the shallow water. Finding food, eating it, and keeping out of the way of its enemies were almost the trilobite's whole life. At last the trilobite died—no one knows why. But the story of the trilobite does not end.

The trilobite's body fell to the bottom of the water. It was washed out by the tides until it lay in quiet water a mile or two from shore. The sea water





Trilobite Fossils
Courtesy of the Milwaukee Public Museum

around the trilobite had lime in it just as sea water has today. Some of the lime from the water settled to the bottom of the sea around the trilobite. Soon the trilobite was covered with limy mud.

The trilobite's body decayed—the soft parts first, and then the shell. Limy mud filled the space left by the trilobite's body. The real trilobite was gone, but a trilobite made of limy mud was in its place. After a long, long time, this limy mud became solid rock of a kind which we call *limestone*.

More and more limy mud settled down on top of the trilobite. In the sea there were a great many little animals with lime in their shells. When they died the lime in their shells helped to make the layer of limy mud above the trilobite thicker.

The rivers brought great loads of mud to the sea, and layers of this mud helped bury the trilobite deeper. Sand was washed out from shore by the waves and was dropped on top of the trilobite. More and more layers of limy mud were piled on it.

Several million years passed. The rivers kept on bringing in mud and lime. The waves kept on washing sand back into the sea. And the shells of countless millions of little sea animals helped make the layers of mud above the trilobite thicker and thicker. The trilobite was now buried under many hundreds of feet of limy and sandy mud. In time the sea above the trilobite grew shallow. At last the floor of the sea became dry land. The layers of soft mud which covered the trilobite turned to solid rock.

On the surface of the ground plants began to grow. They were not much like the plants of today. None of them had any flowers. None of them had broad leaves like the leaves of maple trees. Many of the plants were small and had small leaves or none at all. Little animals much like our centipedes and spiders of today ran about among the plants.

A river flowed over the place where the trilobite lay. Flowing water can wear away rock and soil. Little by little the river cut its way down into the rock that covered the trilobite. But it did not cut its way deeply enough to reach the layer of rock in which the trilobite was buried.

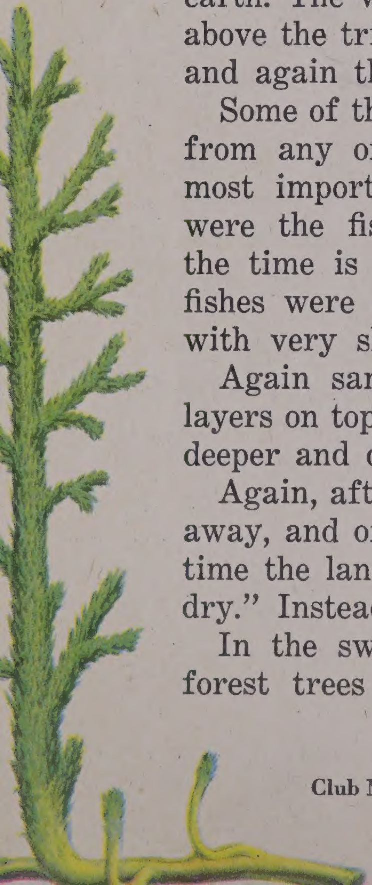
The land above the trilobite did not remain dry land for very long as time goes in the story of the earth. The water in the sea rose higher, or the land above the trilobite sank—it does not matter which—and again there was a sea above the trilobite.

Some of the animals in this sea were very different from any of the trilobite's ancient neighbors. The most important of the newer animals in this sea were the fishes. There were so many fishes that the time is called the *Age of Fishes*. Some of the fishes were covered with armor. Some were sharks with very sharp, strong teeth.

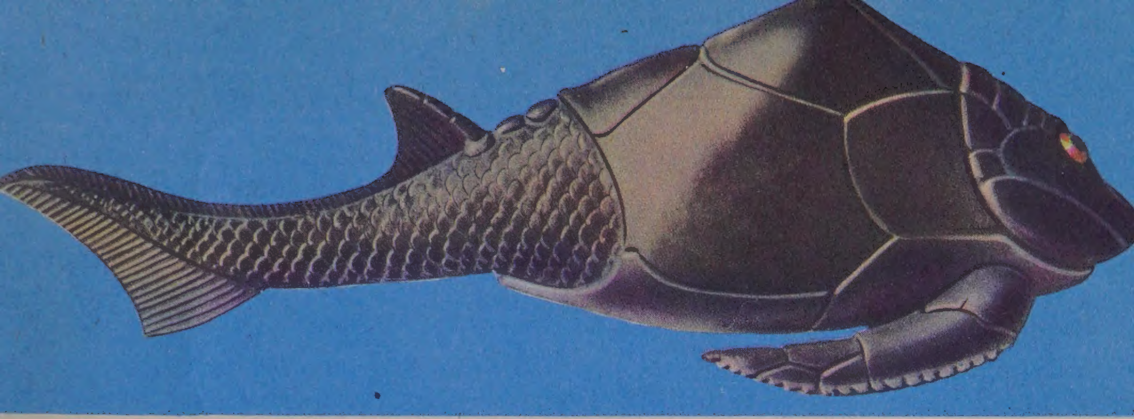
Again sand and mud and lime settled down in layers on top of the trilobite. The trilobite was buried deeper and deeper.

Again, after millions of years, the sea was drained away, and once again the sea bottom was land. This time the land above the trilobite was not "high and dry." Instead, it was swampy.

In the swamps thick forests grew. Some of the forest trees were giant ferns. Others were giant



Club Moss

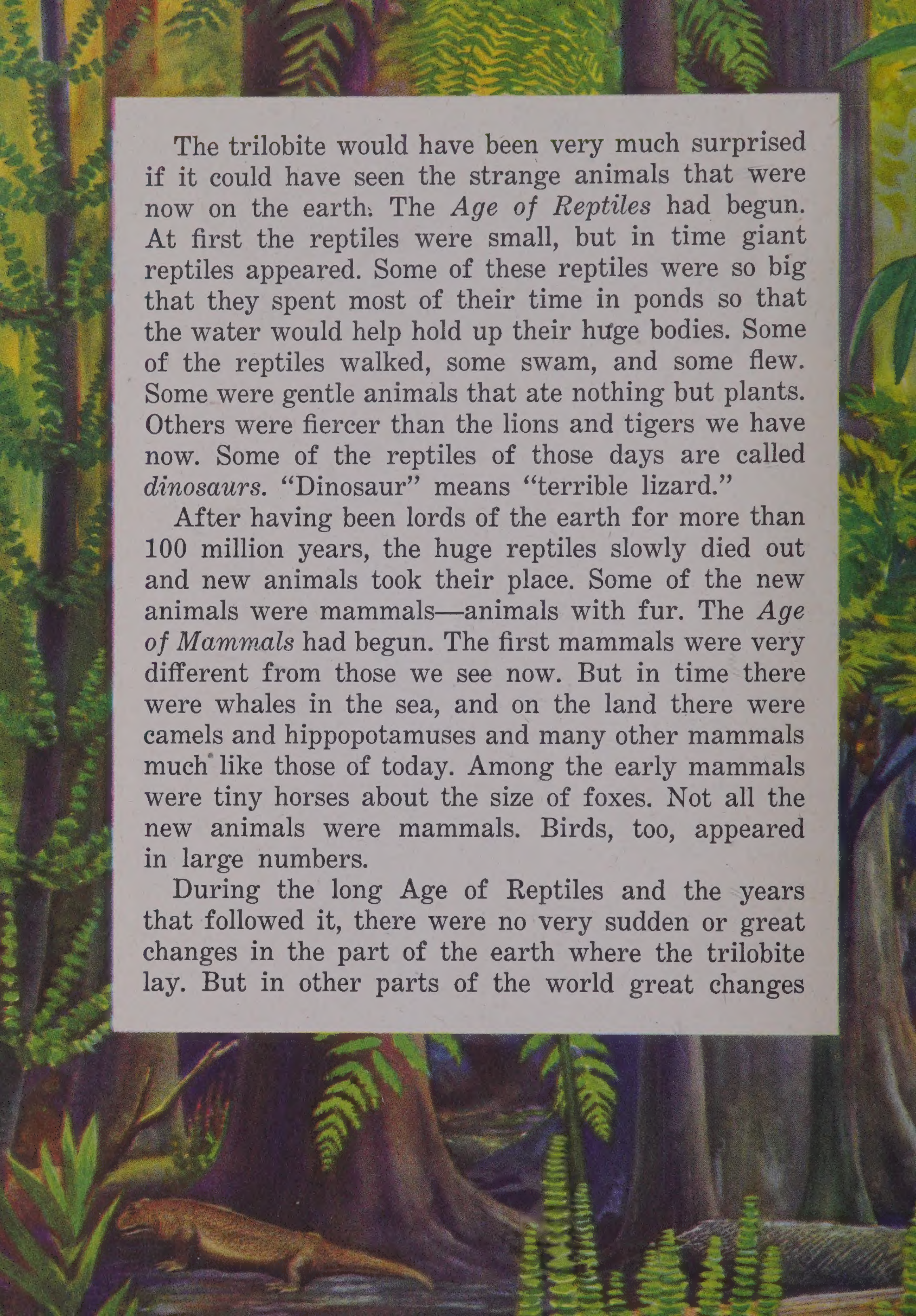


Armored Fish
Courtesy of the Milwaukee Public Museum

horsetails and club mosses. The horsetails and club mosses of today are little plants. Seed ferns, the first plants with seeds, grew in the forests, too. Giant dragon-flies, the largest insects that have ever lived, flew in and out among the trees. Giant cockroaches and spiders ran over the ground. Amphibians, relatives of our frogs and toads, sunned themselves on the edges of the swamps.

For millions of years the land above the trilobite kept rising and sinking. The changes were very slow—you could not have seen or felt any change going on if you had been there. But at times the land was so low that the forests of the swamps were drowned. They were covered with layers of mud and sand and lime. At other times the land was high enough so that the forests grew again in the swamps. At last there were several layers of buried forest above the trilobite. There were layers of sand and mud and lime between the layers of buried forest. As time went on, the layers of buried forest were changed to coal.

Finally, about 225 million years ago, the land above the trilobite rose so high that it was no longer swampy. From that time on it was never again under the sea. The *Coal Age* was over.



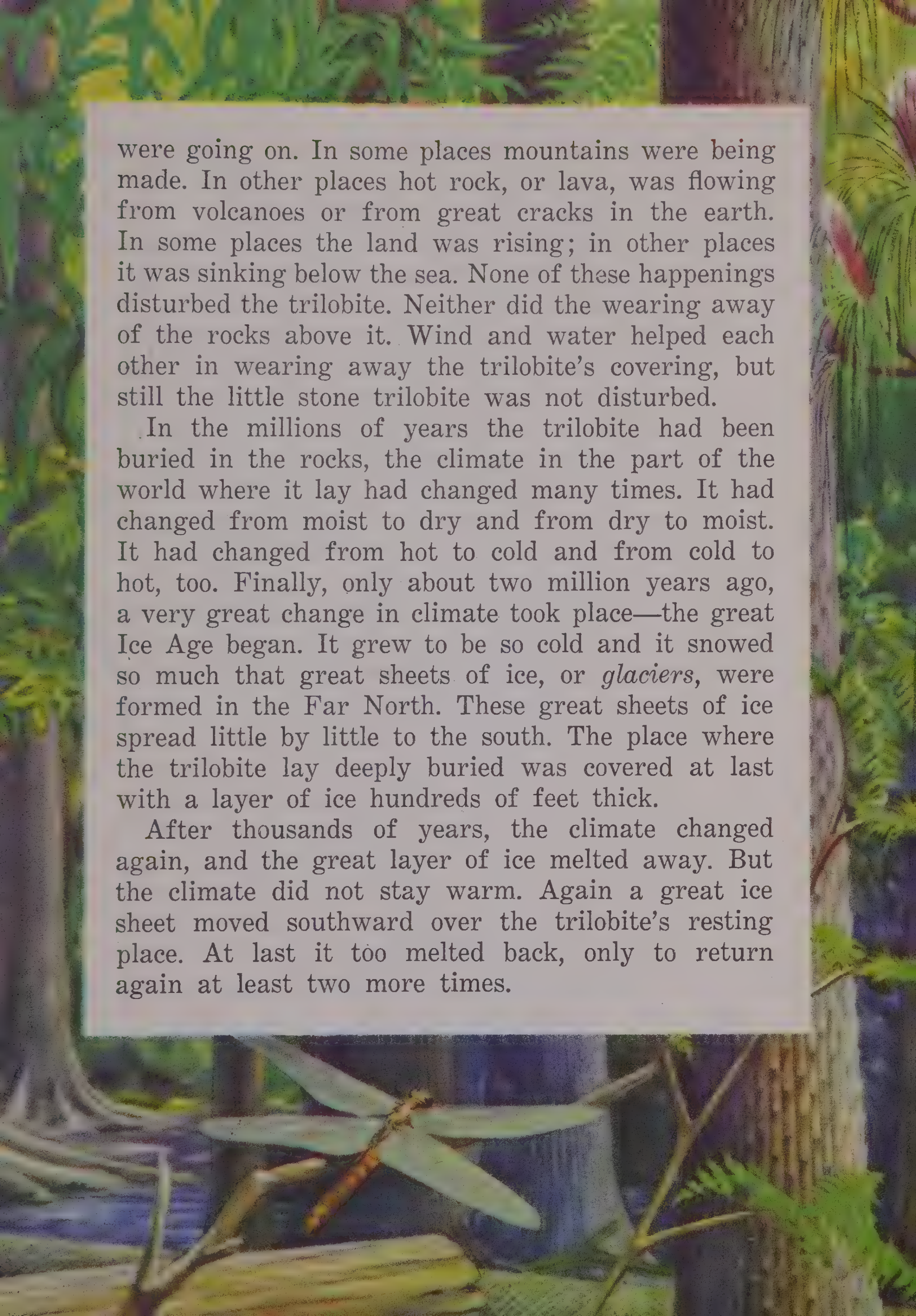
The trilobite would have been very much surprised if it could have seen the strange animals that were now on the earth. The *Age of Reptiles* had begun. At first the reptiles were small, but in time giant reptiles appeared. Some of these reptiles were so big that they spent most of their time in ponds so that the water would help hold up their huge bodies. Some of the reptiles walked, some swam, and some flew. Some were gentle animals that ate nothing but plants. Others were fiercer than the lions and tigers we have now. Some of the reptiles of those days are called *dinosaurs.* "Dinosaur" means "terrible lizard."

After having been lords of the earth for more than 100 million years, the huge reptiles slowly died out and new animals took their place. Some of the new animals were mammals—animals with fur. The *Age of Mammals* had begun. The first mammals were very different from those we see now. But in time there were whales in the sea, and on the land there were camels and hippopotamuses and many other mammals much like those of today. Among the early mammals were tiny horses about the size of foxes. Not all the new animals were mammals. Birds, too, appeared in large numbers.

During the long Age of Reptiles and the years that followed it, there were no very sudden or great changes in the part of the earth where the trilobite lay. But in other parts of the world great changes were going on. In some places mountains were being made. In other places hot rock, or lava, was flowing from volcanoes or from great cracks in the earth. In some places the land was rising; in other places it was sinking below the sea. None of these happenings disturbed the trilobite. Neither did the wearing away of the rocks above it. Wind and water helped each other in wearing away the trilobite's covering, but still the little stone trilobite was not disturbed.

In the millions of years the trilobite had been buried in the rocks, the climate in the part of the world where it lay had changed many times. It had changed from moist to dry and from dry to moist. It had changed from hot to cold and from cold to hot, too. Finally, only about two million years ago, a very great change in climate took place—the great Ice Age began. It grew to be so cold and it snowed so much that great sheets of ice, or *glaciers*, were formed in the Far North. These great sheets of ice spread little by little to the south. The place where the trilobite lay deeply buried was covered at last with a layer of ice hundreds of feet thick.

After thousands of years, the climate changed again, and the great layer of ice melted away. But the climate did not stay warm. Again a great ice sheet moved southward over the trilobite's resting place. At last it too melted back, only to return again at least two more times.



During the great Ice Age, man appeared on the earth. Man was not so big or so strong as some of the other animals of the time, but he made his way in the world because he had better brains. He learned to cut down forests, plant crops, dig mines, and build dams. He changed the face of the earth in many ways.

Man spread far and wide over the earth. In time, America was discovered, and white men came to live here. At last a great city grew up not far from the place where the trilobite lay in the rocks. The people of the city wanted stone to use in building their buildings. They soon found that, not very deep in the ground, there was a thick layer of limestone. They began digging into the ground and carving out blocks of this stone.

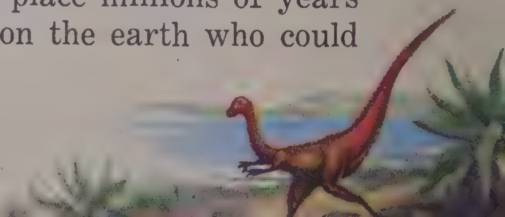
One day a workman noticed a queer stone lump on the edge of a small piece of limestone he had broken off. As he looked at it closely, he decided that it must be some strange kind of animal that had been changed to stone. As you can guess, it was the trilobite about which you have been reading.

The workman sent the trilobite to a museum. The people of the museum called it a *fossil*—the name they give to any trace of a plant or animal of long ago. They put it in one of the museum cases with this label:

TRILOBITE
Age: About 375,000,000 years

The Earth's Diary

The story of the trilobite is a true story—at least scientists think it is. Of course, most of the happenings the story tells about took place millions of years before there were any people on the earth who could

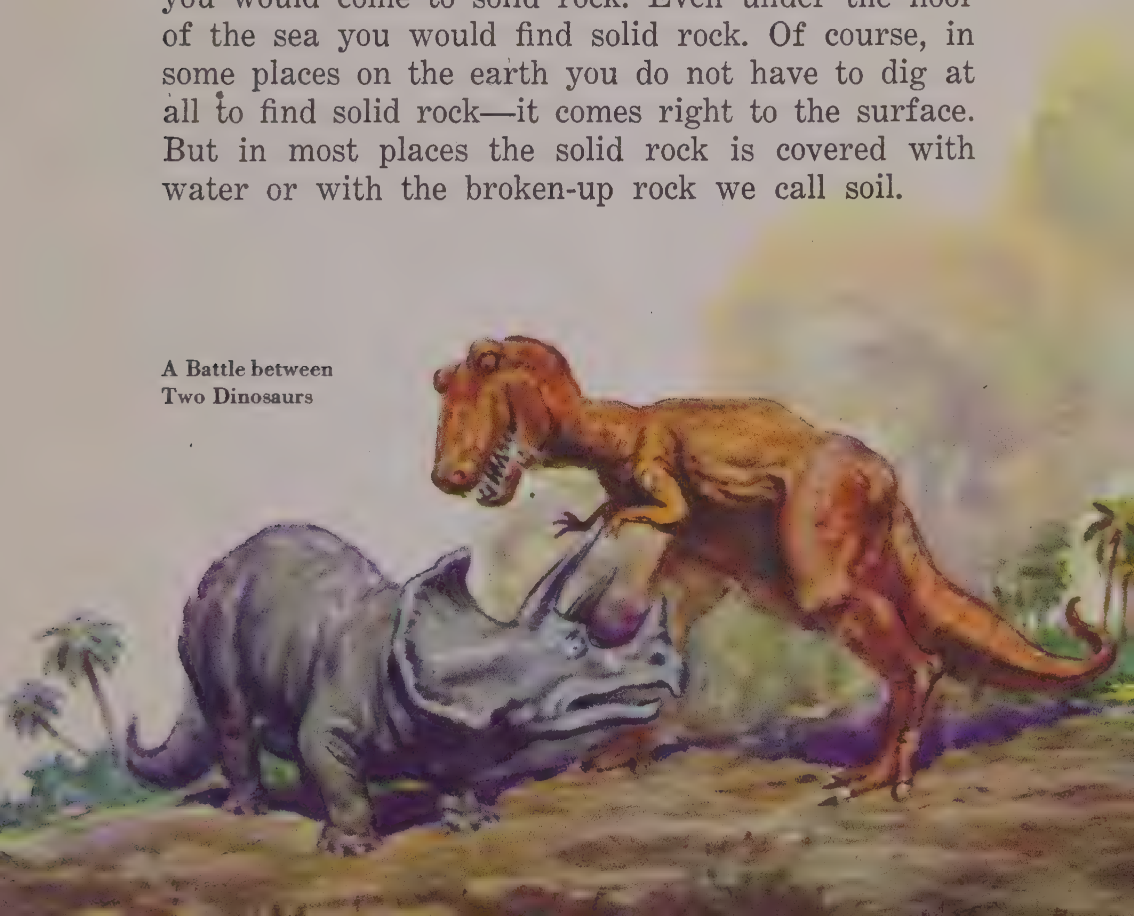


write. In fact, most of these changes took place millions of years before there were any people at all on the earth. How, then, can anyone tell that all the happenings in the story really took place? How does anyone know about the plants and animals of long ago? How does anyone know about the rising and sinking of the land? How does anyone know about the making of mountains and the changes of climate and the great lava flows of early times?

No one would know what happened on the earth before men lived here if scientists had not learned to read the stories the rocks tell us. Almost all of the story of the trilobite was read from the rocks.

If you dug down far enough anywhere on the earth, you would come to solid rock. Even under the floor of the sea you would find solid rock. Of course, in some places on the earth you do not have to dig at all to find solid rock—it comes right to the surface. But in most places the solid rock is covered with water or with the broken-up rock we call soil.

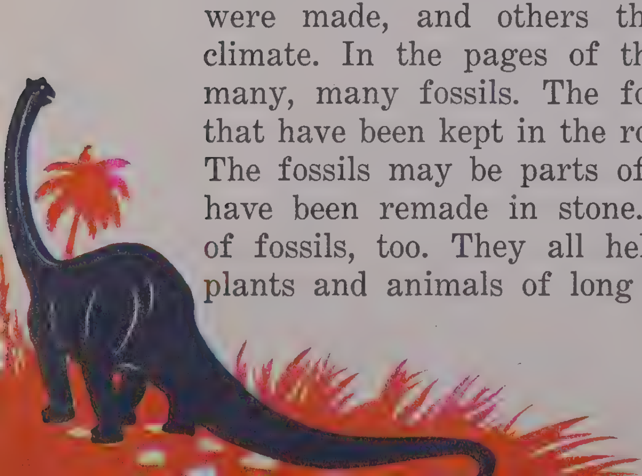
A Battle between
Two Dinosaurs



In many places on the earth, if you kept on digging after you reached solid rock, you would come to layer after layer of rock of different kinds. In those places the outer part of the solid earth—the part we call the earth's crust—is like a giant layer cake. The picture on page 13 shows where a river cut its way down through many layers of rock. You can see in the picture the edges of the layers. In some places there are hundreds of such layers; in other places there are not so many. The soil at the top is like frosting on the cake.

There are hundreds of different kinds of rock that make up the earth's crust. Some of these rocks were made in one way, some in another. By studying the earth to find out how rocks are made, scientists have learned to tell much about what was happening on the earth when the different layers of rock in the earth's crust were formed. The way the different kinds of rock lie on one another helps tell the story of long ago, too. Mother Earth kept in the rocks, you see, a kind of diary of all that was happening to her. We might think of each layer of rock as being a page in her diary.

Some of the pages in the rock diary tell about the seas of long ago. Some tell about the lava flows of past ages. Some tell the story of how mountains were made, and others the story of changes in climate. In the pages of the rock diary there are many, many fossils. The fossils may be footprints that have been kept in the rock for millions of years. The fossils may be parts of plants or animals that have been remade in stone. There are other kinds of fossils, too. They all help tell the story of the plants and animals of long ago. As you can guess,



Grand Canyon
Courtesy of Fred Harvey Studio

some of the pages of the earth's diary tell several stories at the same time.

The earth's rock diary is not easy to read. Some of the pages are found in one part of the world, other pages in other parts of the world. Besides, accidents have happened to some of the pages. Reading the records of the rocks is much like reading a book that has some pages badly torn, some pages partly burned, some pages almost spoiled by water, and some pages put in at the wrong places.

If the layers of rock in the earth's crust had not been disturbed after they were made, the oldest layer of rock in any one place would be deepest down and the youngest nearest the top. But in many places the layers of rock have been folded so that older layers are on top of younger layers.

Many scientists have worked for many years to read the earth's story from its rocks. They do not yet know its whole story. Perhaps they never will, but

Fossil of a Fern Leaf

Courtesy of the Milwaukee Public Museum

each year they are reading more and more of it.

Of two things scientists are very sure. They know that the earth is very old. They know, too, that the story of the earth is a story of many changes.

North America's Ups and Downs

The map on page 16 shows North America as it was at the time the trilobite of our story lived. Probably you would not know that the map is a map of North America unless you were told. Notice that the sea covered most of what is now the great Mississippi Valley. Try to imagine ocean waves lapping the shore in Ohio or Nebraska or Missouri. The trilobite of our story lived in the sea which covered what is now Illinois. You understand, of course, that the trilobite lived many, many millions of years before there were any states.

The first map on the inside of the back cover shows North America as it was at one time during the Age of Coal. The second map shows North America as it was at one time during the Age of Reptiles.

Many more such maps could be given if there were room for them. Scientists have made maps of the land and the sea for many different times in the earth's history. They have made maps not only of North America but of other continents, too. Three maps are enough to show that the story of land and sea is a story of much change. There was land millions of years ago where there is no land now, and there were seas millions of years ago in places that are now dry land.

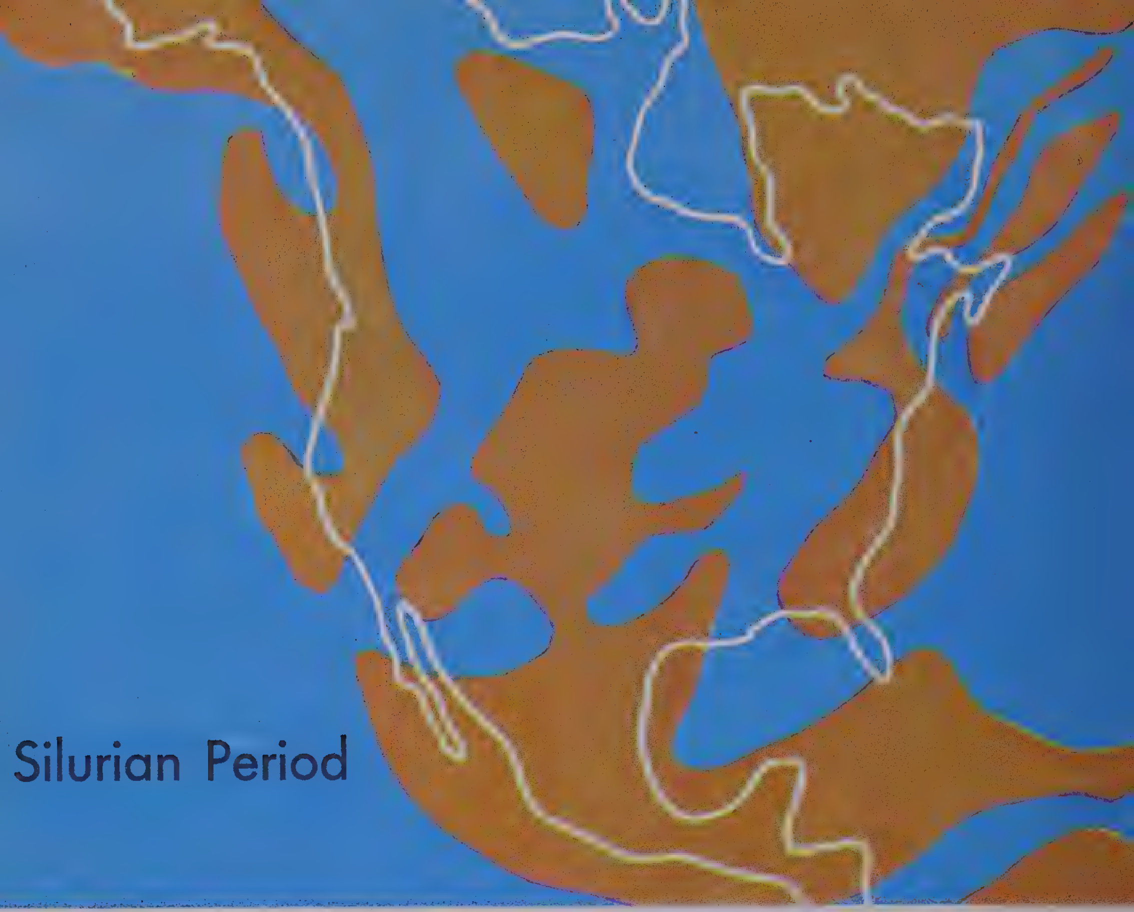
As you have already been told, the rocks tell the story of the changes in land and sea. Certain kinds of rock are made under water. When scientists find layers of these kinds of rock in any region, they know that the region was once under water. When they find in these layers of rock, as they usually do, fossils of sea plants and sea animals, they are even more sure that the region was once covered by the sea.

Rocks Made under Water

Part of the story of the seas of long ago is told by rocks made of sand or of mud or of pebbles. The rivers, as they rush to the sea, pick up mud and sand and pebbles and carry them along. When the water of the rivers reaches the sea, it is slowed up. Then it has to drop part of its load. First it drops the heaviest part—the pebbles. Next it drops the sand. It may carry the very fine particles of mud for miles out into the sea before it drops them. Waves beat on the shores, too, and break up the rocks along the shores into pebbles and sand and mud, which sooner or later are dropped to the floor of the sea.

As the mud and sand and pebbles sink to the bottom of the sea, they form layers on the ocean floor. In time, the particles of mud and the grains of sand and the pebbles in these layers may be cemented together to form solid rock.

Grains of sand cemented together form *sandstone*. Pebbles form *conglomerate* (kon-glom′er-at). Mud becomes *shale* (shāl). As you see, the pieces of rock shown in the pictures on page 18 are pieces of sandstone, conglomerate, and shale.



It is easy to tell sandstone from other rocks by its feel. The grains of sand can easily be felt. Some sandstone is gray, some is yellow, and some is pink or red. Some sandstones are not very well cemented together. Many a piece of sandstone can be crumbled up into sand in a person's hand.

Notice the pebbles in the piece of conglomerate in the picture. Conglomerate is sometimes called "pudding stone" because of the mixture of rock materials in it.

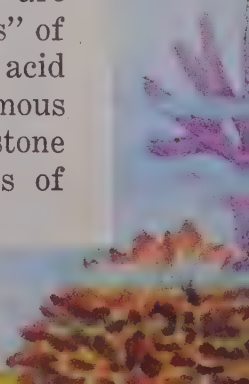
The easiest way to test shale is to moisten it with water and then smell it. It smells like mud. Of course, this muddy smell is not surprising, since shale is made of mud. Shale may be red, bluish-gray, greenish-gray, or black. Like sandstone, it can often be broken up easily.

Rivers carry sand and pebbles and mud to the sea by picking them up and pushing them along. They carry lime and salt in a different way. The water dissolves these materials. River water does not have to drop its load of lime and salt when it reaches the sea. At times, however, it does give up some of its lime, and this lime mixes with mud and settles to the bottom of the sea. Later it hardens into limestone. Salt is left behind when the water of a small sea evaporates. Among the pieces of rock shown on page 19 there are pieces of *limestone* and *rock salt.*

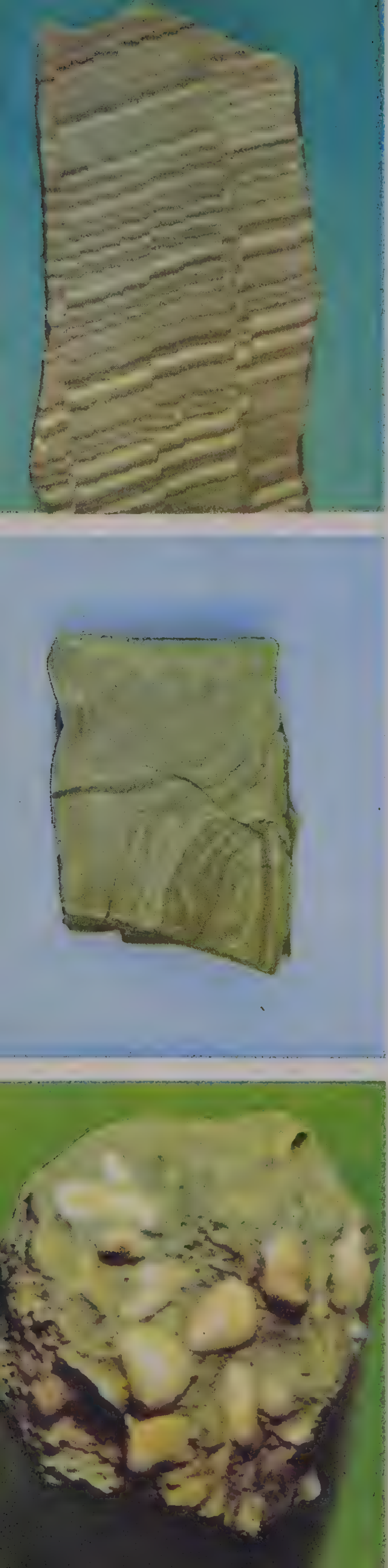
The picture on page 20 shows a piece of limestone so smooth that a picture has been drawn on it by an artist. Most limestone is either white or cream-colored or gray. When scientists find a piece of rock that they think is limestone, they test it by putting a drop of hydrochloric (hy′dro-klo′rik) acid on it. If the rock is limestone, bubbles are formed.

Rock salt is found underground in layers that may be more than 20 feet thick. You can guess that the easiest way of testing salt is to taste it.

Plants and animals helped make some of the rocks that tell us about the seas of long ago. Much limestone is made by little corals. These little animals take lime from the water and build their "houses" of it. When they die, their "houses" are left. The picture on this page shows a few "houses" of coral limestone. Coral limestone bubbles when acid is put on it just as other limestone does. The famous chalk cliffs of England are made of limestone formed from the shells of millions and millions of



Coral



very tiny sea animals. Much other limestone is made of the shells of animals, too.

Coal, as you read in the story of the trilobite, was made under water out of the plants of long ago. "As black as coal" is a common saying, but not all coal is black. Some of it is brown, instead. The best way of telling coal from other brown or black rocks is to put a small piece of it in a fire. None of the other rocks which look like coal will burn.

As rocks are covered deeper and deeper by other layers of rock, the lower rocks may be changed by the weight of the upper layers. Heat from the inside of the earth sometimes helps to change rocks. Water sinking down from above into the layers of rock that have already been made sometimes helps to change rocks, too. In some of the ways in which mountains are made there is a great deal of sidewise pushing. This sidewise pushing is another cause of changes in rocks.

Shale may be changed into *slate.* Slate can be split up into very thin layers. Probably you have often written on a slate blackboard. The next time you write on one, remember that the slate used to be mud in the bottom of some sea. Perhaps

Sandstone
Shale
Conglomerate
Courtesy of the Milwaukee Public Museum

you have noticed that slate has a "muddy" smell, just as shale has, when it is wet.

Sandstone may be changed to *quartzite.* In quartzite you can no longer feel the grains of sand. Quartzite is so hard that paving-stones are sometimes made of it.

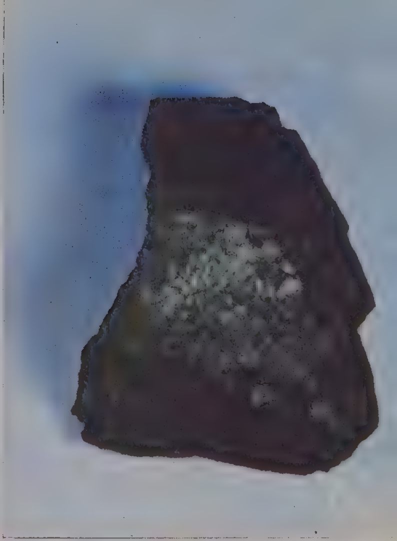
Limestone may be changed to *marble.* Marble may be black, pink, gray, or white. Some marble is streaked with another color. Marble bubbles, just as limestone does, when hydrochloric acid is put on it.

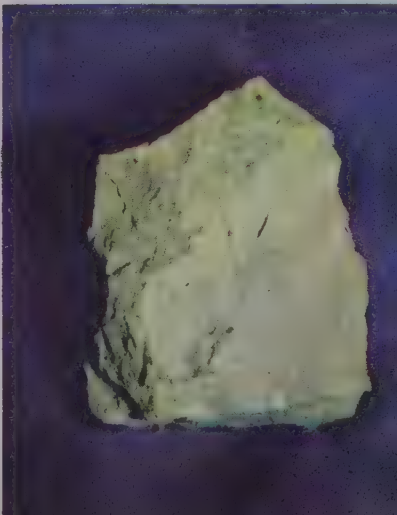
Conglomerate may be changed to *schist* (shist), a rock which is in thin layers. Schist may be made from other rocks besides conglomerate.

Coal may be changed—*soft coal* may be changed to *hard coal.* Hard coal is a cleaner fuel than soft coal.

Small pieces of slate, quartzite, marble, hard coal, and schist are shown in the pictures on page 21.

Coal, shale, sandstone, limestone, rock salt, conglomerate, and the rocks made from them, all help tell us about the seas of long ago. If you should find a little piece of limestone in your back yard, however, it would not tell you that your part of the world had once been under water. A small piece of limestone might have been carried to your back yard





Soft Coal
Rock Salt
Limestone

Courtesy of the Milwaukee Public Museum

from some other part of the world. If, on the other hand, you should find, under the soil in your back yard, a solid layer of limestone or of any other water-made rock, you would know surely that the region had not always been dry land.

As you might guess, rocks may be made on the floors of fresh-water lakes just as they are made on the floor of the sea. Fossils hidden in the layers of rock often help tell the scientists whether the rocks were made in a lake or in an ocean.

Floods of Lava

The mountain in the picture on page 27 is a *volcano*. The red streaks down the sides of the mountain are made by streams of red-hot rock flowing down the mountain. Hot rock which flows out on the surface of the earth is called *lava*.

When lava is coming from a volcano, we say that the volcano is erupting. When a volcano is erupting, lava may be shot high into the air.

The picture on page 26 shows how a volcano would look if you could slice down through it and deep into the earth below. Notice that the hot, liquid rock is coming from deep down in the earth.

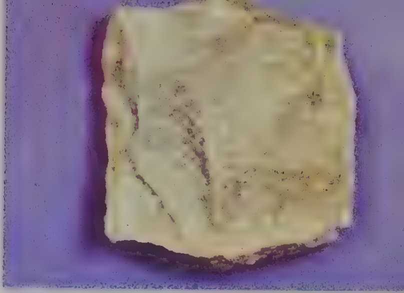
Why, you may wonder, should hot, liquid rock which is deep in the earth ever come to the top of the ground? Sometimes the weight of the rocks above it squeezes it up. It is squeezed out of the earth just as orange juice can be squeezed out of a small hole in an orange. Sometimes steam or some other gas that is formed in the hot rock pushes the hot rock up out of the earth.

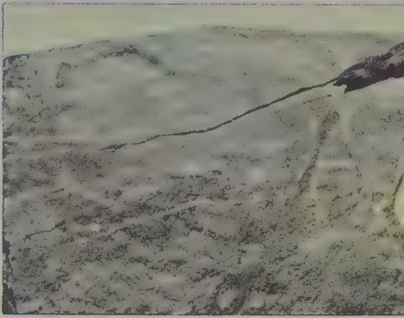
In all of our forty-eight states there is only one volcano that has erupted recently. This volcano is Mount Lassen in California. Twenty-five million years ago the story was very different. Eruptions were very common in the West then. There were great floods of lava.

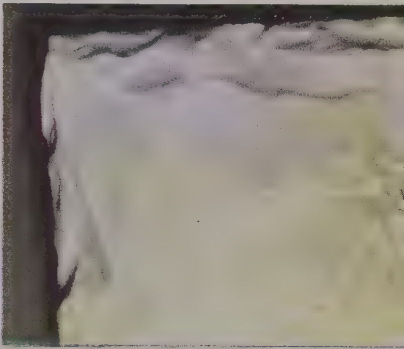
The lava poured out not only from mountains like the one in the picture on page 27 but also from great cracks that were many miles long. In some places the floods of lava were hundreds of feet deep.

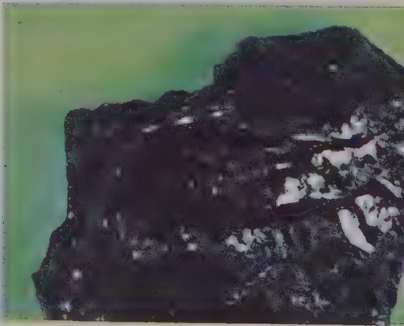
These great floods of lava wiped out rivers just as easily as you could rub off a chalk-mark from a blackboard. They filled up lakes. They buried great forests. We know about these forests because some of the buried trees were *petrified*, or rebuilt in stone, and can still be seen. The floods of lava killed thousands of animals and drove thousands more from their homes.

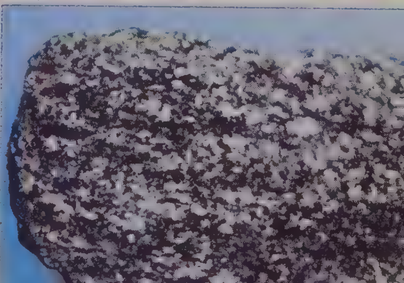
The time 25 million years ago is not the only time in the past when there were great floods of lava. At the close of the Age of Reptiles there were many volcanic eruptions in the western part of our country. Even during the great Ice Age there were eruptions of volcanoes in the West. At that time, you see, the country











Quartzite
Slate
Marble
Hard Coal
Mica Schist

Courtesy of the Milwaukee Public Museum

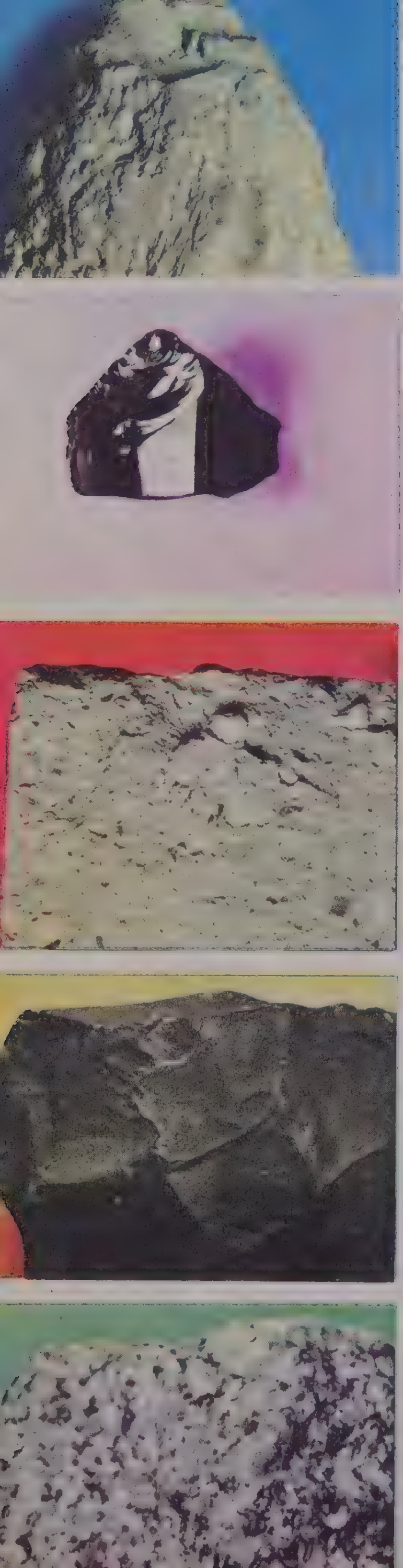
was a furnace in some places and a refrigerator in others. The eastern part of our country has had its floods of lava, too. Some of them were long before the days of the trilobite.

Perhaps in times to come there will again be great floods of lava in this country. We may be very glad that our volcanoes are quiet now. The earth is a much pleasanter place when its volcanoes are quiet.

Igneous Rocks

Scientists have read the stories of the old volcanoes and lava flows from the rocks that are formed when hot, liquid rock cools. Scientists call these rocks *igneous* rocks. "Igneous" comes from the Latin word which means "fire." The pictures on this page show several kinds of igneous rocks.

Pumice (pum′is) is often formed when lava cools very quickly. It is really made from the foam on the top of a stream of lava. It is very light in weight because there are many spaces in it where there were bubbles of gas when it was hot. You can see the spaces in any piece of pumice. Perhaps you have used pumice to clean ink off your fingers. If you have, you will remember that it is pale gray in color.



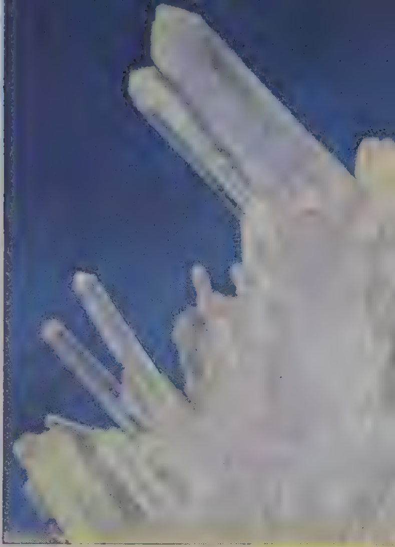
Pumice
Obsidian
Tuff
Basalt
Granite
Courtesy of the Milwaukee Public Museum

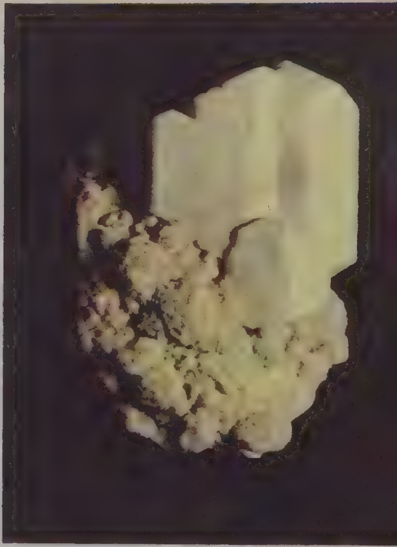
Obsidian (ob-sid′i-an) comes from lava which cools very fast, too. It does not look at all like pumice, however. It has no holes in it, and it is very black and shiny—blacker and shinier than coal. It looks like black glass—in fact, it is often called "volcanic glass."

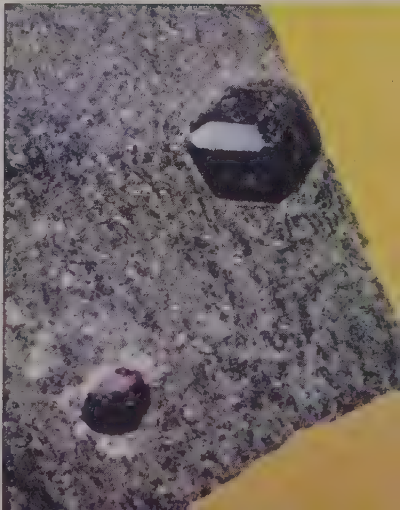
As you have already been told, at times lava is shot out of a volcano with such force that it goes high into the air. This lava hardens into small pieces of rock before it reaches the ground. If the bits of rock are very small, they are called "volcanic ash." If they are larger, they are called "volcanic cinders." Sometimes volcanic ash is cemented together to form solid rock after it falls to the ground. Rock made in this way is dull gray. It is called *tuff*.

Basalt (ba-salt′) is a very common igneous rock. It is dull black. Basalt comes from lava which cools rather slowly. All of the rock you see in the picture on page 28 is basalt. Basalt often breaks up into six-sided columns when it cools.

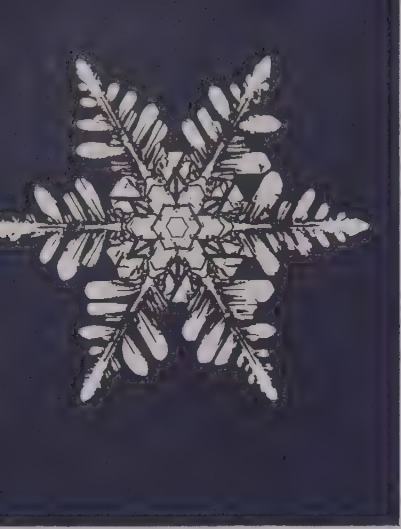
Granite is another very common igneous rock. Granite is always made underground. The hot, liquid rock of which it is made does not come clear to the surface. Often granite may be seen on the surface of the







Quartz Crystals
Feldspar Crystals
Garnet Crystals
Courtesy of the Milwaukee Public Museum



ground now because the rocks above it have been worn away. To form granite, the hot, liquid rock must cool very, very slowly. The materials rocks are made of are called *minerals*. The hot rock which forms granite cools so slowly that the minerals in it separate themselves from one another and form crystals.

Probably you have seen crystals of many kinds. The pictures on this page show three common kinds of crystals. The pictures on page 23 show crystals of several different kinds of minerals that are found in rocks. The upper two pictures on page 25 show other crystals found in rocks.

Granite is always a speckled rock because the crystals in it are never all the same color. Two of the minerals pictured on page 23 are always found in granite. These two minerals are quartz and feldspar. Notice that the quartz crystals are six-sided and that the feldspar crystals are box-shaped. Quartz, as you see, looks like glass. Feldspar is sometimes pink, sometimes white, and sometimes gray or green or cream-colored. If the feldspar in a piece of granite is pink, we call the granite red granite. If the feldspar is white, the granite is gray.

Snow Crystal
Alum Crystals
Sugar Crystals

Granite usually has a dark mineral in it, too. This dark mineral may be black mica like that shown in the top picture on this page. It may be some other dark mineral, instead. As you would expect, the crystals in granite are so crowded together that they are not perfect in shape.

Granite is sometimes changed by heat and the weight of the rocks above it into a banded rock called *gneiss* (nīs). The bottom picture on this page shows a piece of gneiss.

There are many other kinds of igneous rocks—far too many to be told about here. Some have big crystals in them; some have crystals so small that they cannot be seen without a magnifying glass. Some are light in color; some are dark. Some are light in weight; others are heavy. All of them help tell the story of volcanoes and lava flows.

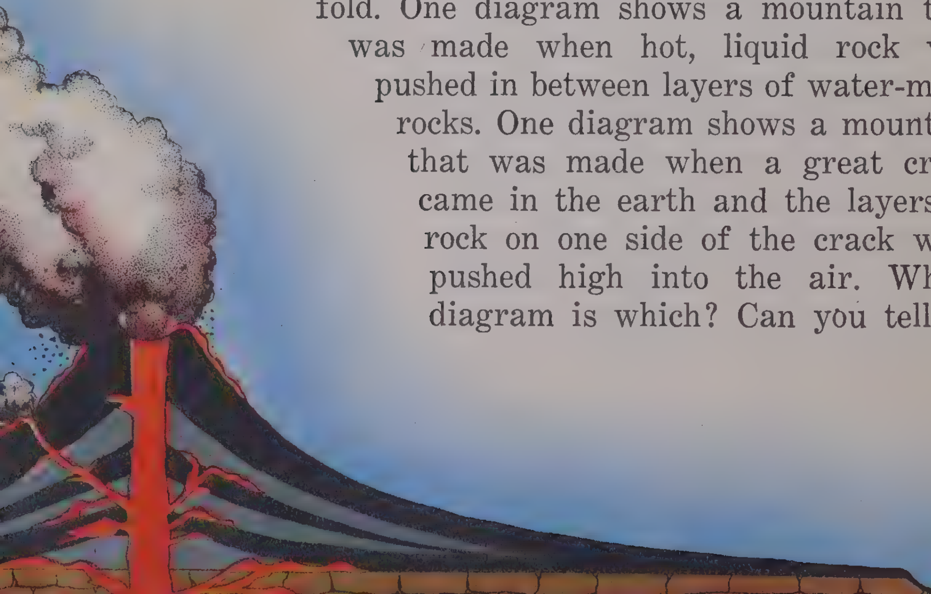
Of course, you cannot read the story of a volcano or a flood of lava from a small piece of igneous rock. A small piece of basalt in your back yard, for example, would not tell you that there had once been a great lava flow there. But whenever you find a mass of igneous rock like the one in the picture on page 28, you may be sure that the region was once flooded with lava.

Mica Crystals
Tourmaline Crystals
Gneiss
Courtesy of the Milwaukee Public Museum

Mountains Old and New

You have already been told about one kind of mountain—a volcano. Perhaps you wonder why lava so often comes out of the top of a mountain instead of coming out of a hole in level land. The pictures on page 30 will help show you. In the beginning, there was no mountain at all above the opening that reached down to the hot rock deep in the earth. Lava began to pour out of the opening. It flowed in all directions, but some of it cooled before it had gone very far. The sheet of lava was thicker near the opening. Some of the lava was shot high in the air. It fell to the ground as ashes and cinders. Of course, most of it fell near the opening from which the lava had been shot. The ashes and cinders helped build a hill around the opening. More lava poured out, and more ashes and cinders fell. At last there was a high mountain around the opening.

The diagrams on page 31 show some of the other ways in which mountains can be made. One diagram shows a mountain that was made when the rocks of the earth's crust were pushed up into a great fold. One diagram shows a mountain that was made when hot, liquid rock was pushed in between layers of water-made rocks. One diagram shows a mountain that was made when a great crack came in the earth and the layers of rock on one side of the crack were pushed high into the air. Which diagram is which? Can you tell?



Scientists could read the stories of mountains easily if the layers of rock in the mountains were as easy to see as they are in the pictures. But of course they are not. Scientists cannot slice mountains down through the center and look at the layers of rock.

Sometimes streams help the scientists who are trying to read the stories of the mountains. The picture on page 13 shows how a stream can cut its way down into rocks so that scientists can see the edges of the layers. Scientists have learned to tell, too, from the edges of layers of rock that come to the surface of the ground how the layers lie underneath the surface.

Of course, the kinds of rock in mountains also help tell the story of how mountains are made. If all the rocks of a mountain are water-made rocks, the mountain cannot be a volcanic mountain.

Most mountains are made very slowly. Only volcanic mountains are made quickly. The making

Basalt Columns
Courtesy of the Milwaukee Public Museum

of a mountain usually takes thousands or even millions of years.

The rocks mountains are made of help tell how old the mountains are. Some mountains are young mountains. Some are very old. In our own country the Rocky Mountains are young. They are only about 60 million years old. Some of the mountains in the eastern part of our country are more than three times as old.

People used to think that all the mountains here on the earth had been here since the world began. They might think so still if scientists had not learned to read the stories of the rocks.

The Great Ice Age

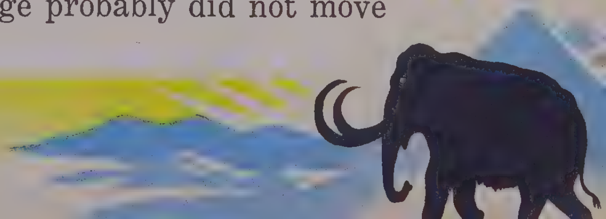
How there came to be a great Ice Age no one is sure. Of course, it was caused by a great change in climate, but no one knows what caused this change. Just before the Ice Age a large part of the earth was covered with forests. Some scientists think that the trees of these forests used up so much of one of the gases in the air that the air was no longer a very good blanket. At any rate, the climate became so much colder that, in the Far North, the snows of winter, instead of melting away during the summer, stayed on the year round. The snow of one year after another was piled up until finally it was many feet deep. The snow little by little became ice, as it does in many snow fields today.

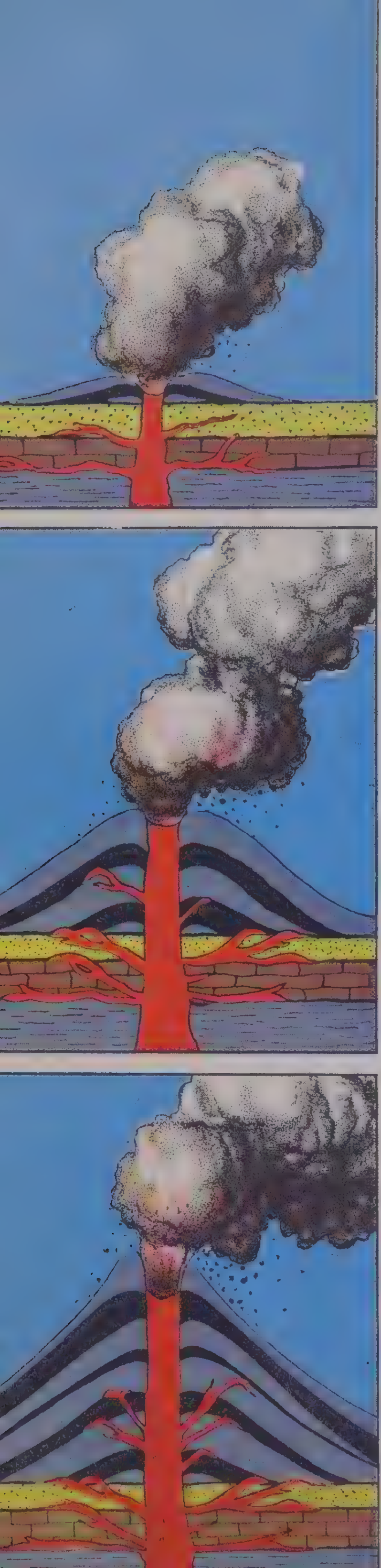
As the sheets of ice became thicker in the Far North, their edges were pushed farther from the center. If you will take a ball of clay, put it on a smooth surface, and watch the edges of it move outward as you push it down slowly in the center, you may get a little idea of how the edges of the ice moved outward. The ice moved in the same way that rivers of ice—valley glaciers—now move down mountain valleys from snow fields at the tops of the mountains.

The ice kept on growing thicker. Soon it was more than a hundred feet thick, then more than a thousand. As it grew thicker, it spread farther and farther to the south.

As the ice moved southward, it ripped off big boulders and carried them along with it. It cut off the tops of the hills it moved over. In North America it scraped off the soil of much of what is now Canada and brought it to the United States. It blocked up old lakes and rivers and helped make new ones.

The animals of the north, of course, had to move to the south to keep from being killed by the ice. They did not have to hurry to get away from it, however, for its southern edge probably did not move





forward more than a foot a year, perhaps not so much. Of course, the plants over which the ice moved were killed. They could not run away. Great trees as well as little plants were crushed into powder under the moving ice. In one way, however, the plants did move south. No one plant could move, but the seeds of a plant could be carried toward the south and could grow into plants there. As the ice came closer, some of the seeds of these plants might be carried farther to the south, and so on and on.

After thousands of years—fifty thousand, perhaps—the climate changed again. It grew much warmer in the north. The ice melted back little by little from the edges. The animals that had been driven to the south came back to the north again—not the same ones, of course, but their great-great-many-times-great-grandchildren. Many of the kinds of plants that had been driven from the north came back, too. Some of them, indeed, went farther north than they had been before.

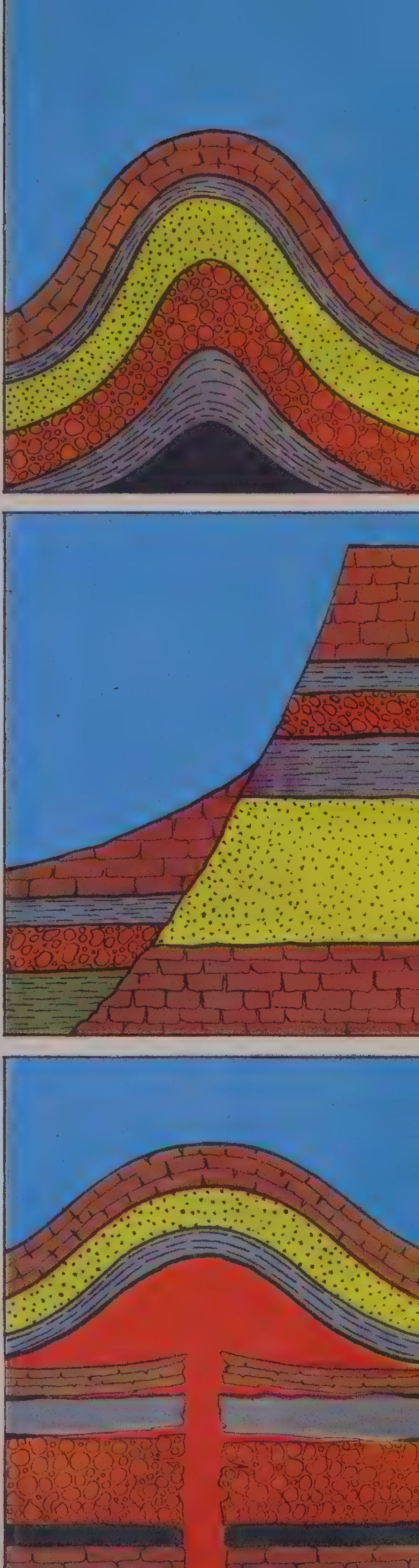
The "summer" did not last very many thousand years. Again the ice sheets pushed their way southward. Again thousands and thousands of square miles of Europe and North

America were buried under them. At last "summer" came again, and the ice melted back. This "summer" was very long. Then it was followed by another "winter" of thousands of years, another "summer," and still one more long "winter."

The map on page 33 shows how much of North America was once covered by ice. Try to picture what you would have seen if you could have flown in an airplane then from where San Francisco is now to what is now New York.

You would have seen no signs of the great ice sheet until you got past the Rocky Mountains. Of course, the Rocky Mountains had huge glaciers in the high valleys, but these were not a part of the great ice sheet itself. As you flew over the plains east of the mountains, you would have seen signs of a very cold land. You would have seen, for example, mastodons and mammoths. In what is now Nebraska you would have come to the western edge of the ice sheet itself.

From the time you reached the edge of the ice sheet until you finished your journey, there would have been almost nothing to see but ice. From high in your plane, the whole northeastern part of the



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United States would have looked like a great skating-rink. If you had been down near the surface, however, you would have seen that the surface of the ice was not smooth but was broken by deep cracks. These cracks were caused by the movement of the ice sheet over hills and valleys. When you reached the eastern coast, you would have seen, floating in the sea, icebergs broken from the edge of the ice sheet.

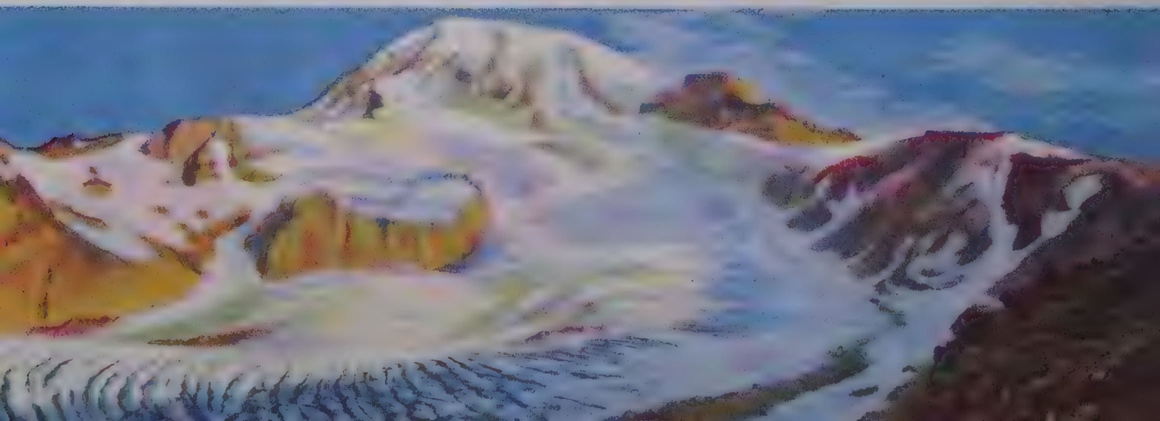
How do the rocks tell about the great Ice Age? The pictures on pages 34 and 35 will help you see.

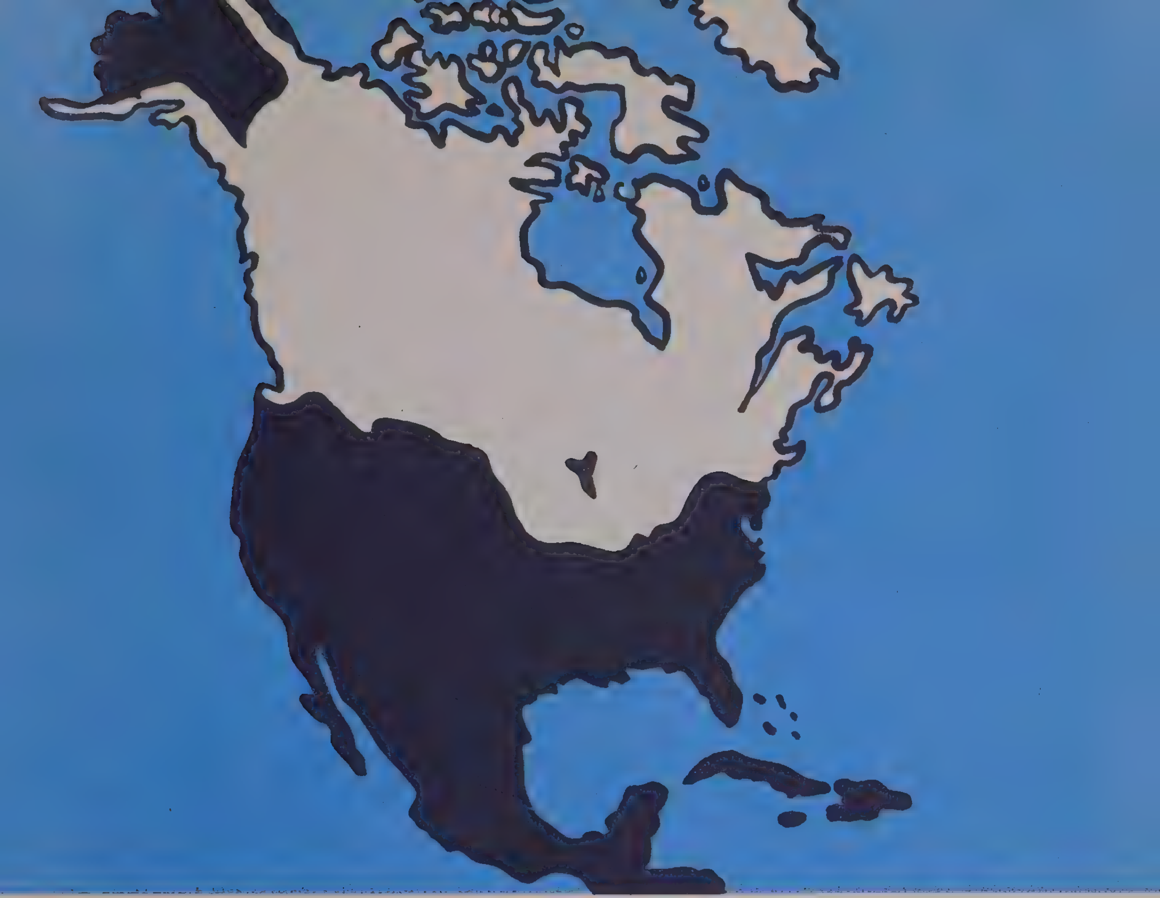
The big boulder in the picture on page 34 was carried from far to the north by the ice. It probably rolled onto the top of the ice from the top of a mountain or hill. When the ice melted, the boulder was left behind to help tell the story of the great Ice Age. There are many, many boulders like the one shown in the picture.

The rock in the picture on page 35 was scratched by the ice as the ice moved over it. Bits of rock were frozen into the bottom of the sheets of ice. The ice with the sand and pebbles frozen into it was like a great piece of sandpaper being pushed by a giant. It made scratches on the bare rocks it went over just as a common piece of sandpaper makes scratches on a polished table.

A Glacier of Today

Courtesy of the Milwaukee Public Museum





Hills made of sand and pebbles the ice pushed along in front of it are another sign of the great Ice Age. The hills were left when the ice melted away.

Will there ever be another ice age? No one knows. Scientists have now found, deep in the rocks, signs that there had been other ice ages before the great Ice Age. Perhaps there will be others. Perhaps, indeed, we are not yet out of the great Ice Age. You remember that between the advances of the ice there were long "summers" when the climate of North America was as warm as or even warmer than it is now. Perhaps we are in one of the "summers" between the advances of the ice. It may be that the ice of the Far North will once more spread toward

Glacial Boulder
Courtesy of the Milwaukee Public Museum

the south and will wipe out our farms and forests and cities. But there is no sign now of another advance of the ice. If another comes, it cannot come for many thousands of years.

How Old Is the Earth?

Scientists believe that the earth is at least two billion years old. It may be much older.

Imagine that you have a book in which each page stands for a million years in the earth's history. The book is very thick—there are at least 2,000 pages in it. Each page, let us say, has 50 lines of print on it, and each line is made up of 20 words. Each line, then, stands for 20,000 years, and each word for 1,000 years.

If there are 2,000 pages in this book you are imagining, pages 1999 and 2000 stand for the time since man first appeared on the earth. The last half of the last line on page 2000 stands for the time in which people have been able to keep records. The last half of the very last word on page 2000 stands for the time since Columbus discovered America. Does thinking of such a book help you understand that the earth is very, very, very old?

The chart on the inside front cover tells a part of the story of the earth. But it does not tell the whole story. It shows only a little of the Age of Simple Plants and Animals, which was several times as long as the Age of Trilobites. Still earlier there was a period of millions of years when there were no living things on the earth. If the chart were made long enough to tell the whole story of the earth, it would be about five times as long as it is.

As you look at this chart, remember that all that it shows and all that anyone knows about the story of the earth before people learned to keep records has been read from the rocks.

Do You Know Now?

1. The earth is very old.
2. The history of the earth is a story of great changes.
3. Rocks tell the story of the earth before there were people on the earth.
4. Rocks made under water tell where the old seas used to be.
5. Rocks made from lava tell about the volcanoes and lava flows of long ago.
6. Fossils tell the story of the plants and animals of long ago.
7. The rocks of a mountain tell how the mountain was made.

Rock Scratched by Glacier
Courtesy of the Milwaukee Public Museum

8. Scratches on rocks, big boulders brought down from the north, and hills of pebbles and sand left by the ice help tell the story of the great Ice Age.

See for Yourself

1. Hunt for small pieces of limestone. Perhaps you can test at school the pieces of rock you find which you think are limestone.
2. If there is a slate blackboard in your schoolroom, wet a small part of it with a damp sponge or cloth. Notice that the slate smells like mud.
3. Try to find pieces of all the kinds of rock shown in the pictures on pages 18, 19, 21, and 22.
4. If there is a science museum near you, visit it if you can to see any fossils which may be there.
5. If you have a piece of pumice, try to make it float on water.
6. Heat a cupful of water in a pan until the water is boiling. Take it off the fire and add powdered alum until no more will dissolve in the water. Then fasten one end of a string to a stick. Lay the stick across the top of the pan so that the string will hang down in the solution. Let the solution cool. Try to keep it from cooling very fast. Crystals of alum should form on the string. Are alum crystals the same shape as any of the other crystals in the pictures on pages 23, 24, and 25?
7. If there are any buildings made of stone near where you live, try to tell of what kind of rock each one is made.
8. Perhaps you live in a part of the country that was covered by ice during the great Ice Age. If you do, look for signs of the ice sheets.

Kodachrome Cover by FRED HARVEY STUDIO
Grand Canyon, Arizona

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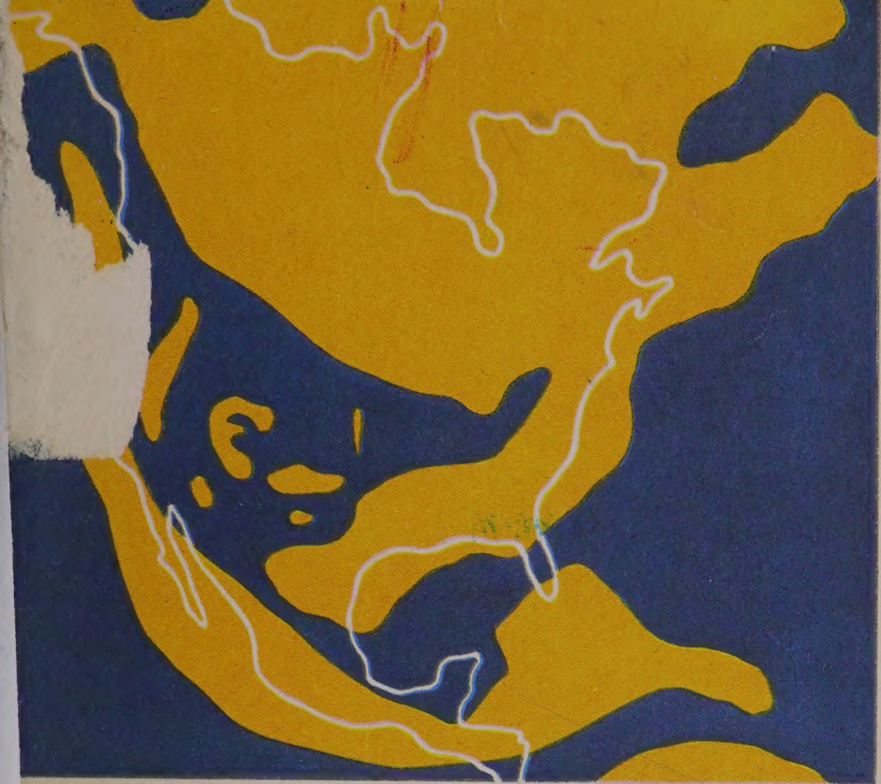

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CRETACEOUS PERIOD